Results from the Industrial Assessment Center (IAC) Steam Tool Bechmarking Support Project

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Introduction

The U. S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) BestPractices effort is developing a number of software tools to assist industrial energy users to improve the efficiency of their operations. One of the software tools that have been developed is the "Steam System Scoping Tool." The Steam Scoping Tool is an Excel spreadsheet that can be applied by industrial steam users to: a) evaluate their steam system operations against identified best practices; and b) develop a greater awareness of opportunities to improve their steam systems.

The Steam Scoping Tool was developed by BestPractices Steam (the Best Practices and Technical subcommittee of BestPractices Steam); the tool was initially released in August 2000.

In June 2000, the Industrial Assessment Center (IAC) Steam Tool Benchmarking Support project was started. DOE IACs provide energy, waste, and productivity assessments at no charge to small to mid-sized manufacturers. These assessments help manufacturers maximize energy efficiency, reduce waste, and improve productivity. The assessments are performed by teams of engineering faculty and students from participating universities/IACs across the United States.

The IAC Steam Tool Benchmarking Support project had three main tasks:

Task 1: Compile steam system benchmarking data from past IAC steam assessments;

Task 2: Perform one-day focused steam system assessments to test new steam assessment tools and to develop new steam benchmarking data; and

Task 3: Document the results of the Task 2 efforts.

Six IACs participated in this project:

- University of Massachusetts, Amherst;
- North Carolina State University;
- Oklahoma State University;
- San Francisco State University;
- South Dakota State University; and
- University of Tennessee, Knoxville.

This paper summarizes the results for the key efforts of the project—the results from the 18 steam system assessments, and the results of the evaluations of the Steam System Scoping Tool.

Results from the 18 IAC Steam System Assessments

Each of the six IACs performed three one-day steam system assessments in industrial plants. As part of the effort to perform these assessments, two BestPractices Steam assessment tools were utilized:

a. The Steam System Scoping Tool; and
b. The Steam System Survey Guide. This guide (presently in draft form) has been developed by Dr. Greg Harrell from the University of Tennessee, Knoxville. It is a reference document that provides a technical basis for identifying and assessing many potential steam system improvement opportunities. Although the Survey Guide was provided to the IACs to use as a resource, the main focus of this project was to evaluate the usefulness of the Steam Scoping Tool.

Table 1 lists the industrial plant types for the one-day steam assessments. The IACs obtained annual data on the fuel cost to produce steam for 15 of the assessed plants. These annual fuel bills ranged from about $79,000 to $14,800,000 per year; the average for the 15 plants was about $1,600,000 per year.

The key activities associated with each of the 18 steam assessments were the following:

a. Working with the plant staff to obtain answers to questions in the Steam Scoping Tool;

b. Performing the individual steam assessments;
c. Documenting the results of each of the individual steam assessments in summary reports; and
d. Documenting the results of each of the completed Steam Scoping Tool evaluations.

Individual summary reports were prepared for each of the 18 steam assessments. In addition, completed Steam Scoping Tool spreadsheets for each of the plant assessments were prepared.

Table 1: Plant types for the 18 IAC steam benchmarking support steam assessments

Cheese and Whey Products
Chemicals
Corrugated Containers (2)
Fabric Dying Facility
Frozen Food Producer
Hardwood Mouldings
Industrial Cleaning Compounds and Sanitizers
Inorganic Chemical Intermediates
Pulp and Paper Plants (3)
Redwood Lumber
Rubber Tires
Shopping Cart Manufacturer
Styrofoam Cups
Textiles
Vinyl Flooring

Steam improvement opportunities, cost savings, implementation costs, and anticipated paybacks were identified for each of the 18 steam assessments. Eighty-nine improvement opportunities were identified. Sixty-eight of the identified improvements had yearly savings less than $20,000 per year; 21 of the identified improvements had yearly savings greater than $20,000 per year.

The total identified annual energy savings from these assessments was $2,800,000; the average yearly savings for each of the identified 89 improvements was about $31,500 per year. The total identified implementation cost for the 89 was about $1,600,000; the average overall payback for the 89 improvements was about seven months.

Table 2 shows data for annual fuel costs to produce steam and annual identified savings, as a percent of annual fuel costs, for the 18 steam assessments. For eight of the assessments, annual identified savings were greater than nine percent of the annual fuel costs. The average identified energy savings for the 18 steam assessments was 12.5 percent of the individual plant energy bills.

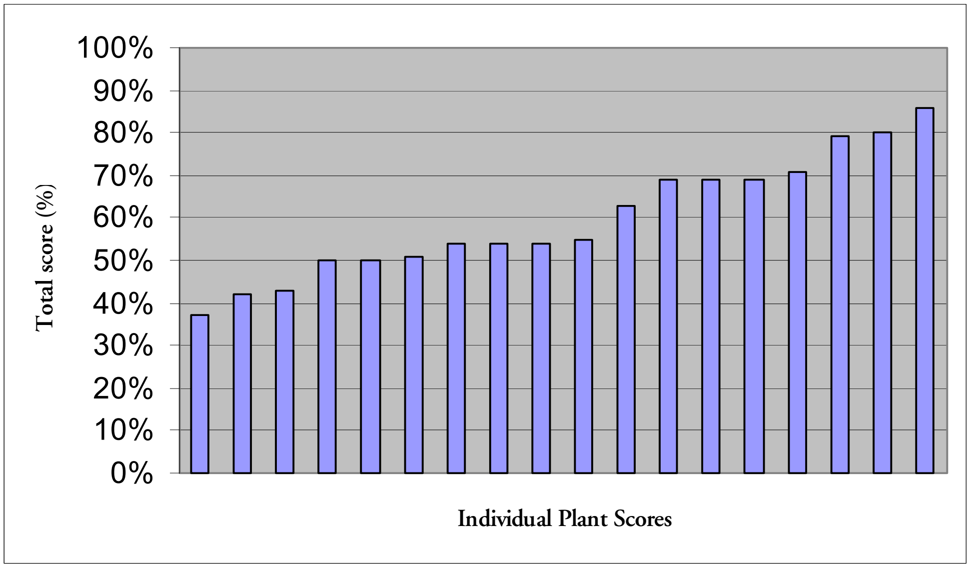
The Steam System Scoping Tool [1] includes seven worksheets associated with identifying steam system improvement opportunities:

a. Introduction;
b. Steam System Basic Data;
c. Steam System Profiling;
d. Steam System Operating Practices – Total Steam System;
e. Steam System Operating Practices – Boiler Plant;
f. Steam System Operating Practices – Distribution, End Use, and Recovery; and
g. Summary Results.

Table 2: Annual fuel cost to make steam and identified annual energy savings as percent of annual steam fuel cost, for the 18 IAC steam assessments.

Plant	Annual Fuel Cost to Produce Steam ($)	Annual Energy Savings as Percent of Annual Steam Fuel Cost
1	$532,940	1.8%
2	$1,579,231	2.6%
3	$157,862	3.4%
4	$261,558	4.3%
5	$661,391	4.6%
6	$173,222	5.6%
7	$14,790,000	6.0%
8	$244,124	6.2%
9	$3,131,040	6.7%
10	$1,224,997	7.0%
11	$1,000,000	9.4%
12	$78,934	10.3%
13	$136,791	13.9%
14	$415,337	15.4%
15	$1,744,680	20.2%
16	$183,889	25.3%
17	$619,016	33.5%
18	$1,456,000	49.2%

Figure 1: Steam System Scoping Tool total scores from IAC steam assessments



A steam user has to answer 26 questions to complete the Steam Scoping Tool; the maximum score that can be achieved in completing the Steam Tool (100 percent) is 340 points. Figure 1 illustrates the individual plant scores achieved for the IAC steam assessments. The individual plant scores ranged from a low of 37.1 percent to a high of 85.9 percent.

Table 3 shows average question responses and standard deviations of question responses for the IAC steam assessments. The results shown in Table 3 illustrate the following:

a. For three of the general areas—Steam System Profiling, Boiler Plant Operating Practices, and Steam Distribution, End Use, and Recovery Operating Practices—the average overall score was about 50 percent. For example, out of 90 points available for Steam System Profiling, the average score for the 18 IAC steam assessments was 44 points;

b. The highest scores were achieved in the area of Steam System Operating Practices—out of 140 available points the average score was 102 points (about 73 percent);

c. The scores varied the most (highest relative standard deviation) for the Steam System Profiling area—for this area, the standard deviation of responses was 28 points out of the available 90 points. This suggests that the plants differed the most in their responses to the Steam Profiling questions.

Steam Scoping Tool Evaluation Results

The IACs prepared an individual summary report for each of the 18 steam system assessments. In addition, each participating IAC prepared a separate report summarizing the overall results of each of their efforts.

A key part of the Steam Scoping Tool evaluation reports was to identify the following types of information:

a. How useful was the Steam Scoping Tool to the plant personnel?
b. How can the Steam Scoping Tool be improved?
c. How can the usefulness of the Steam Scoping Tool to plant personnel be improved?

All of the individual evaluation comments on the Steam Scoping Tool have been reviewed, and many of the suggested improvements will be included in the next release of the Steam Scoping Tool. Some of the key comments made by the IACs are summarized below:

a. A number of the IACs indicated that the question on Options for Reducing Steam Pressure (PR1) needs to be improved. Many facilities will not have the option of reducing pressure using backpressure turbines, and the Steam Tool should reflect this.

SCOPING TOOL AREAS AND QUESTIONS	POSSIBLE SCORE	AVERAGE, IAC RESPONSES	STD. DEVIATION, IAC RESPONSES
1. STEAM SYSTEM PROFILING			
STEAM COSTS			
SC1: Measure Fuel Cost to Generate Steam	10	7	5
SC2: Trend Fuel Cost to Generate Steam	10	6	5
STEAM/PRODUCT BENCHMARKS			
BM1: Measure Steam/Product Benchmarks	10	4	5
BM2: Trend Steam/Product Benchmarks	10	4	5
STEAM SYSTEM MEASUREMENTS			
MS1: Measure/Record Steam System Critical Energy Parameters	30	18	9
MS2: Intensity of Measuring Steam Flows	20	5	7
STEAM SYSTEM PROFILING SCORE	**90**	**44**	**28**
2. STEAM SYSTEM OPERATING PRACTICES			
STEAM TRAP MAINTENANCE			
ST1: Steam Trap Maintenance Practices	40	24	7
WATER TREATMENT PROGRAM			
WT1: Water Treatmen—Ensuring Function	10	8	3
WT2: Cleaning Boiler Fireside/Waterside Deposits	10	9	3
WT3: Measure Boiler TDS, Top/Bottom Blowdown Rates	10	8	4
SYSTEM INSULATION			
IN1: Insulation—Boiler Plant	10	9	3
IN2: Insulation—Distribution/End Use/Recovery	20	14	8
STEAM LEAKS			
LK1: Steam Leaks—How Often	10	6	5
WATER HAMMER			
WH1: Water Hamme—How Often	10	8	3
MAINTAINING EFFECTIVE STEAM SYSTEM OPS.			
MN1: Inspecting Important Steam Plant Equipment	20	16	6
STEAM SYSTEM OPERATING PRACTICES SCORE	**140**	**102**	**18**
3. BOILER PLANT OPERATING PRACTICES			
BOILER EFFICIENCY			
BE1: Measuring Boiler Efficiency -- How Often	10	6	4
BE2: Flue Gas Temperature, O_2 , CO Measurement	15	9	6
BE3: Controlling Boiler Excess Air	10	6	4
HEAT RECOVERY EQUIPMENT			
HR1: Boiler Heat Recovery Equipment	15	6	6
GENERATING DRY STEAM			
DS1: Checking Boiler Steam Quality	10	3	4
BOILER OPERATION			
GB1: Automatic Boiler Blowdown Control	5	3	3
GB2: Frequency of Boiler High/Low Level Alarms	10	9	2
GB3: Frequency of Boiler Steam Pressure Fluctuations	5	4	2
BOILER PLANT OPERATING PRACTICES SCORE	**80**	**45**	**13**
4. STEAM DISTRIBUTION, END USE, RECOVERY OPERATING PRACTICES			
MINIMIZE STEAM FLOW THROUGH PRVs			
PR1: Options for Reducing Steam Pressure	10	5	3
RECOVER AND UTILIZE AVAILABLE CONDENSATE			
CR1: Recovering and Utilizing Available Condensate	10	8	3
USE HIGH-PRESSURE STEAM TO MAKE LOW-PRESSURE CONDENSATE			
FS1: Recovering and Utilizing Available Flash Steam	10	1	3
DISTRIBUTION, END USE, RECOVERY PRACTICES SCORE	**30**	**14**	**6**
TOTAL STEAM SCOPING TOOL SCORE	**340**	**205**	**47**
TOTAL STEAM SCOPING TOOL SCORE (%)		**60%**	**14%**

b. Many of the plant personnel who completed the Steam Scoping Tool felt that it helped them to understand areas where they could improve their steam systems.
c. A number of the plant personnel indicated that they would not have completed the Steam Scoping Tool if they had not been selected to have a free steam system assessment. The responses from the IACs suggest a number of ways to enhance the usefulness of the software tool; for example: 1) provide information on cost savings associated with different improvement opportunities; 2) provide feedback to steam users, after they complete the Tool, providing more details on how improvements can be made; and 3) provide plants with corresponding summary results from other plants to illustrate how their scores compare with other similar plants.
d. A number of the IACs suggested that some measure of comparison be provided on the relative merits of different scoring ranges, e.g. 300-340: excellent, 250-299: very good, etc.
e. Finally, a number of the IACs suggested that improving the overall formatting of the software tool would improve its usefulness.

Summary and Conclusions

In summary, this was a successful project. When the project was started, the Steam System Scoping Tool was about to be released, and there was no measure of how useful the software tool would be for assessing steam systems or where the software tool could be improved. As a result of the project, a number of areas for improving the Tool and the usefulness of the software tool to steam users have been identified.

The results from the 18 steam system assessments will also prove valuable to the overall BestPractices Steam effort.

Acknowledgements

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References

1. *The Steam System Scoping Tool: Benchmarking Your Steam System Through Best Practices*, Dr. Anthony L. Wright (Oak Ridge National Laboratory) and Glenn Hahn (Spirax Sarco Inc.), 23rd National Industrial Energy Technology Conference, Houston, TX, May 2001.